D 617
.692
B644

RARE BOO
Bonwill

RARE BOOK

THE UNIVERSITY OF PENNSYLVANIA
LIBRARY
OF
EVANS DENTAL
INSTITUTE
School of Dentistry

D617.692
B644

GIFT OF
EDWARD C. KIRK

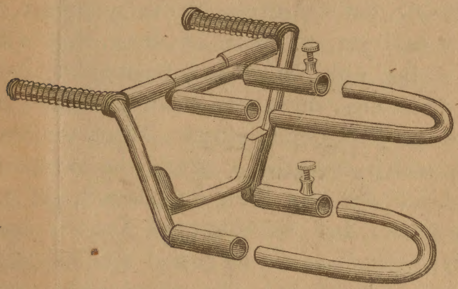
Dreka

The Thomas W. Evans Museum & Dental Institute
LIBRARY
School of Dentistry University of Penna.

The regular meeting was held June 6th, 1885, at the office of Dr. Bonwill, 1721 Locust street, President Darby in the chair. The following paper was read:

GEOMETRICAL AND MECHANICAL LAWS OF ARTICULATION. ANATOMICAL ARTICULATION.

BY W. G. A. BONWILL, D. D. S.



Although I have been invited to read you an essay upon this subject, I do so with reluctance, from the fact that it has been quite twenty-six years since I first discovered the Law and applied it to the needs of dentistry; and during this time have never been asked, until now, by any Society to read a paper thereon.

I can well conceive, however, a reason, and believe it to be from the apathy and repugnance of the modern dentist to mechanical dentistry. Not because he is so perfect in the art of preservation of the teeth, but from an idea born illegitimately, "*it is not so professional.*" This is well, if it could blot out the need; until then, all of us should do what we can to elevate it by making use of every appliance that shows merit. The action of quite every society of cutting off discussions on such topics by "voting for the next subject on the programme," is enough to crush out the spirit from those who have ability in this branch. Be it said to the credit of many dentists, I have been asked to write up and place the apparatus on the market.

It was not patented but presented to the profession as soon as I had completed and proven it, I made one effort to place it on the market, but as soon as it was found to fill the place of what would have brought greater profit to the dealer it was tabled at once, and this one which I obtained of a dealer was patented by the party, supposing the same principles were embodied; but, being ignorant of anatomy and the geometrical law involved, it was "still-born."

This action very much disgusted me, and I saw no chance to do my

443593

duty to you except by my own private enterprise, running the risk of losing all I might advance. I am sorry to say there are many good things that are thus crushed by the dealer and manufacturer unless they can have their way.

I have thought it but due to mention these facts to vindicate myself against any charge of selfishness for withholding this "Anatomical Articulator," which forms the basis of my essay; and, in my own opinion, is not the least of what I have endeavored to do for you.

After more than thirty years of active life in dentistry, I am fully persuaded that of all that constitutes dentistry proper, the mechanical forms the basis. And yet, to make anything that is beautiful in our Art, especialy in vieing with Nature in matching the teeth, we must be more than mere mechanics, more than capable of filling a tooth or treating an abscess; we must be dental artists. When we come to place in a set of teeth upon which depends so largely the expression of the face, from the soul beneath, we must bring to our aid, not only the laws of mechanics and geometry, but the beauties of Art. It is not enough that we accurately adapt the plate to the gums: that we so grind the teeth to the plate as so be water-tight; that we so make every joint that it cannot be distinguished; that we so polish the plate over symmetrical curves, that the tongue cannot find the least fault; we must do something besides this; we must impart *action* to these otherwise whited sepulchres; we must instil life therein, or our labor will be in vain. A tooth may be elegantly shaped and colored, yet if it lacks the proper shape for the person for whom it is intended and is unskillfully set in the arch, it is a failure. The blocks from the same mould set by different operators, may vary in effects in every case. To get proper effects you should have a number of blocks of the various shapes, colors and sizes and try them under the lips until your judgment tells you which to use. Your taste can be so cultivated that you will be apt to criticise your own selections.

I shall use the term articulation instead of occlusion, for the very good reason that it is more in keeping with the functions or the motions of the jaw. If there was but one movement to the lower jaw, and that up and down, we might possibly say occlusion. But this latter term applies more properly to the shutting the lips or closing the mouth, and not to the motion of the lower jaw dependent on the articulation of the same at the Glenoid cavity, where the articulation is universal. Articulation is a word of action throughout, while occlusion answers to the mere act of closing the teeth and lips and keeping them closed; one is active, the other passive. Before we can comprehend then what constitutes true articulation of artificial teeth, we must look at the anatomy of the human jaw and its functions.

We find from twenty-eight to thirty-two teeth in each jaw, arranged in such manner that no two strike directly against each other, but antagonizing in such a manner as to prevent the whole denture from becoming very irregular, which would be the case if striking one against another. By this arrangement, when one tooth is lost, the regularity of the arch is not interfered with. As necessary as this is in nature, it is not positively necessary to follow it in artificial work, although for the sake of harmony it should be done.

It will be found in 95 per cent. of cases that the upper teeth project over the lower, and the depth of overbite varies as the depth of the cusps of the bicuspids are deep or shallow; and the ramus will be found to come upward and backward in relative proportion to the length of the cusps and the overbite.

One point of very great importance has not been lain down in general or special anatomy—the peculiar tripod arrangement of the lower jaw forming an equilateral triangle.

From the centre of one condyloid process to the other, four (4) inches is about the average; and it will be found that from this same centre of the condyloid process to the median line at the point where the inferior centrals touch at the cutting edge, is also four (4) inches. It is strange it should have been overlooked; but it only shows, when studied in a geometrical and mechanical sense, the great wisdom in our formation. It varies slightly, but never more than about one-fourth of an inch, which would make but a trifling difference in describing the arc of a circle. You will perceive that in setting your artificial teeth a one-fourth inch the radius of the circle would not materially alter the articulation. Without such an arrangement the teeth would have to be flat on their grinding surfaces to admit of lateral movement. Besides, you would not have the beautiful and wise curvature at the ramus, for equalizing the force applied to the teeth in all directions.

Imagine the human jaw jointed at the pharynx, or as you see in the ordinary brass articulators. Do you suppose that there would be any greater wisdom displayed in such hinging or articulating a part destined to such varying motions and powerful wrenching force? No! The study of this one part of the head and jaws shows one of the most striking designs of a Great First Cause; and, when studied, you will see that every part of our frame is made by a positive law and to subserve definite purposes; such law being in consonance with geometry and physics and mechanics. We must see the true use or function of the jaw and the teeth, and the food destined for us, and how it should be comminuted; there is no chance work about it! There is law and order pervading every part; the jaw forms a perfect triangle, for the purpose of bringing into contact the largest amount of grinding surface of the bicuspids and molars, and, at the same time; to have the incisors all come into action during these lateral movements.

You will also find that from the cuspids, the bicuspids and molars run in nearly a straight line instead of a curved one back towards the condyloid process, enabling them to keep the largest amount of surface always presented for mastication. Another thing which has never been explained by anatomists or naturalists, is the law of the normal relation of the upper to the lower incisors. The normal jaw should overjet and also have a corresponding underbite. Without such a law the incisors would lose largely their functions, that of incising on the principle of a pair of scissors. Where the incisors strike directly upon each other, the power to cut off food is very much lessened. The length of cusp of bicuspids and molars prove the law.

Another unobserved fact and law will hold good. Where there is an overbite and underbite, just in proportion to their depth will be the length of the cusps of the cuspids, bicuspids and molars. By drawing two lines from a common centre, answering to the condyloid joint, to the centre of the lower jaw at the incisors, four (4) inches distant, the distance between the lines grows less as you go from A to B, the centre of motion; and if the depth of bite is an eighth of an inch, then when you come to the bicuspids, the cusps are shorter and the molars still less; and, if there were any teeth at the condyloid process there would be no depth of cusps. So that when you see a first superior bicuspid you can very well tell from the length of the cusps whether the jaw from which it came had a depth of underbite of one-sixteenth or one-fourth of an inch. Where the teeth all strike fairly one upon the other and no overbite, then you have no occasion for cusps. And if originally there, but a flat surface they would soon be worn off from the abnormal articulation.

Another unobserved fact in connection with the law of articulation: when there is an underbite there will always be a corresponding curvature of the lower jaw at the ramus, the upper jaw corresponding to it. This provision of articulation is most wise, carrying out still more fully the exact law by which the anatomical movements of the lower jaw for perfect mastication is governed. So beautiful and so mathematical a design cannot but call forth our admiration and wonder; and the study of no other part of the human body will give one a clearer idea of infinite wisdom. This movement we will find in the artificial sets arranged upon this law. In the natural the incisors are really the first to be arranged; though the first molars emerge first, to assist in the more perfect mastication of food and to keep the jaws at the proper distance. The incisors show a definite fixedness of purpose to arrange themselves after their typal shape, and to form the overjet and overbite at a given depth, for the accommodation of the bicuspids and molars which are soon to appear, having cuspids of a definite length, so that the law of articulation which has been premeditated to a certain typal shape and construction, be carried out. Then, if the general law, which holds good in 95 per cent. of the cases, is followed—if the underbite is one-fourth of an inch at the incisors—the teeth posterior to the cuspids will have a depth of cusp shorter in proportion to the *underbite* of the *incisors*, as they go backward toward the centre of motion at the condyloid process.

You will also find that the grinding surfaces of the bicuspids and molars have a typal shape—allowing them to meet with all their surfaces touching—for an express purpose, after a preordained and established law, from which the greatest area is gained for mastication; and that the inner cusps of the lower teeth are as necessary as the outer of the superior, when laterally moved. The law is still further carried out in the curvature at the ramus, from the second bicuspid to the third molar, to permit of all the surfaces on one side to be in contact, while the other unused side is only partially so. The nearly straight line of arrangement from the cuspids to the last molar is also in keeping with the underbite. You may well ask, just here, "will this law hold good in an artificial articulator such as I use, applied to setting of artificial teeth?" As soon as you once attempt to apply this principle you must certainly grasp this law, so wise and beautiful. You may have varieties or forms, but the general law will hold good, and where there has been much latitude or varying from it by abnormal mixtures of races or types, if nature is given a fair chance to right herself, she will return to the normal standard of mathematical and mechanical precision; to do otherwise would annihilate creation. Cells free to arrange themselves must develop the original creation, and perpetuate and keep it to the perfect standard, by selecting the highest type of perfection in shape, strength, beauty, etc.

I must be pardoned just here for deviating from the original to introduce some new thoughts in close relation to the subject. Were it not that a law or system is at the beginning before a creative act, that is in unison with an end, there could be no fixedness of purpose or result in propagating life. There must be a type or specified shape, which must run through all life, most beautifully exemplified in mechanics in making all parts interchangeable. The cell must have a specific power to reproduce and perpetuate itself to all infinity, being as perfect as in the beginning, after the law was ordained and promulgated. No known organism has changed its number of cells, their function or power; nothing has been added and nothing obliterated; and the same law holds good in their combination for building up an organism and establishing a type; and although it may be interfered with by injudicious and ignorant mixing of the races, yet there is a certain limit when life is forfeited and nature commences anew from the same stand-point of law and order. If I am correct in this I must necessarily run counter to the Darwinian theory, that nature is from age to age making a "fitter type," and that we are only a more perfected change and type of the chimpanzee. The law was absolute perfection in the beginning, and when organization and types are seemingly changed, it is only for the moment; they must go backward, and not forward, to reach normality, otherwise all life would have long since become extinct. Environment effects only superficial change in minor exterior points, but cannot annihilate or change the organism or type. If it were true what deformities in the teeth would occur, if their shapes and arrangement in middle and old age could be fixed upon posterity. I can readily see where the early extraction of the teeth will affect the posterity, not in changing their type, but in diverting nutrition from this region, until nature fails to supply the organs with pabulum for their healthy organization, thus becoming so weak that caries is inevitable. We may extract as many as we please, and even early in life, but it will have this effect only; and at no time, however remotely could the eruption be prevented, as nature would not tolerate a congenitally toothless man to live and perpetuate his progeny. He would be so far retrograded, that without the organs of mastication, food could not be so prepared, that "life would be worth living." Man may apparently change from disobedience to law, but the penalty must be paid ultimately.

We have this law well illustrated, in the growth of the hair; if cut too often in early life, and kept so, nature will supply enough material only for such short growth, and resist any attempt to make it grow longer. Were we for a generation to remove one of the kidneys, if it could be possible, and maintain life, nature would go on making two kidneys, but weaker ones, until the family would become extinct altogether from imperfect nutrition, as in the growth of hair.

Could you but stand beside me while I arrange a set of teeth in this articulator, you must become converted to my system as founded on law and not on chance. There is no other part of the human body that will permit of thus handling and unfolding, and again rearranging. No other that stands outside its own organic workings that will permit such demonstration. It is the key to the revelation of nature's inner workings, and unfolds, without a *missing link*, what we were, absolutely perfect in cell and organism for the inception, and simply in conformity to an infinite and all-wise law which cannot be blotted out. The teeth, individually, have been a great factor in science; and when they can be looked at from the point of view herein laid down and hitherto undeveloped, their significance will be magnified; and if we, as dentists, but take up the work as only belonging to our specialty, and scientifically prosecute it, our honors and standing will be enhanced.

Let me repeat the points which I claim as guides for the setting of artificial teeth, being after the study of human anatomy:

First. The human jaw forms an equilateral triangle. Taking the base from condyle to condyle (the centre of each), which averages four inches, the other arms of the triangle run from the condyle to the median line of the incisors of the lower jaw, also four inches long. This, I say, is not laid down in any anatomy.

Second. That in ninety-five per cent. of the cases of the upper jaw projects over the lower, and the depth of underbite varies from three-eighths of an inch to a sixteenth, and that but about five per cent. of articulations have the incisors to come directly in union, which is the law of exception or abnormality.

Third. The ramus of the lower jaw has a definite curvature answering to the depth of the underbite, and the cusps of the bicuspids and molars correspond in length to that underbite, and all preordained from the type to be organized.

Fourth. The arch, instead of being of horse shoe shape as in artificial dentures generally, the teeth forming the abatments of the arch, running from the cuspids on either side, look almost directly in a straight line to the centre of the condyloid process. The arch should not be contracted at the molars.

Fifth. The teeth grow out of the arches to a definite length or point, and no further without a mechanical irritation is set up about the investing membrane.

Sixth. The specific shape of the inner and outer cusps of the bicuspids and molars are not without design, and go to establish the perfection of the law.

Upon these bases I shall found the science of articulation, and apply it to the arrangement of all artificial substitutes, changing to suit individual peculiarities. The query here naturally arises to those who have never looked into the philosophy of this matter, whether these peculiarities are necessary, and if it is possible to utilize them in our artificial dentures? and, if so, how can it be done by any of the articulators now in the market, or can it be done at all by any human device? To all these inquiries I answer in the affirmative.

As to the necessity, it should need no argument to convince you that an artificial denture should correspond to the natural one in every respect as nearly as can be approached. It may be a question with you how nearly art and mechanics can imitate the natural movements and expressions.

Has there ever been any rule heretofore given by which you can regulate your beginning and ending with any kind of design? Have you any chart, system or plan to go upon, such as the plot or sketches by which an architect, artist or sculptor can bring forth his ideal? No! I say most emphatically. Look at all the sets of teeth made, I care not from whose hands they come, and you will not find one made after any special law to suit the individual case. Not that no sets have ever been made that have not been serviceable or look well, or where no taste has been manifested; I have seen many, but how much more useful and life-like they can be made by following the system as found in the natural jaw. I remarked it is so strange that these points should have been overlooked so long. To have examined the human jaw critically would have led to the plan at once. But we have acted on the principle that artificial teeth can only admit of the up and down or hinge-like movement. To allow of the lateral motion is thought to be impracticable, as it would throw or upset them, and render them difficult to keep in place. The regular horse-shoe shape has been adhered to up to the present, for fear that if the molars were placed outside the arch, the plate would tilt, and mastication be impossible. To give to the teeth the greatest advantage, you are taught by some to let the cutting edges of the incisors meet squarely, and have no overbite. If there has to be overbite, then the arch must be so large and wide, more than normal.

You are taught that it is vandalism to grind the antagonizing surfaces of teeth, as if there was but one magnate to see them, the manufacturer of the teeth. You are also taught that but one side or cusp of the bicuspids and molars can be made to antagonize the outer. As I have studied the matter in its manifold bearings, and as my fort is in mechanics, I speak as having authority; and, if practice is of any value in establishing theory, I am prepared to give it to you in various ways, and attest that the adaptation of such work in the mouth holds good to the law as it does in this articulator I now present. So that when you have fitted in this device on the law laid down here, a set of teeth for any jaw, you can rely upon it, that if you had the jaw itself in your hands, you could not approach more nearly to what is demanded. In some cases there is need of touching a cusp here and there, but to a very trifling amount.

Let me enter, then, upon the merits of this anatomical articulator and the plan of setting teeth by its use I told you that it was founded upon the measurement and movements of the human jaw. The distance from centre to centre of the condyloid process you will find is about four inches, the same from the condyles to the median line in the lower jaw at the top of the cutting edge of central incisors. This, with the up and down and lateral movements constitute the mechanical construction of the human jaw. This you must observe is a fixed principle, and it is easily seen why this form of a triangle has been adopted in man. This triangle can only be found within a perfect circle in which you have the greatest breadth and area of surface. No other geometrical angle would have given such perfect beauty and symmetry to the face. The compactness brings the largest number of teeth nearest the centre of motion. The double joint permits the greatest strength and the easiest lateral movement with the greatest range of this at the least expense of power and compass. It permits the largest number of teeth to antagonize at every movement, and not least of all this very triangle is the means by which nature develops the typal shape of the ramus, and of the formation of the jaws, the underbite, etc.

It will be observed, that in making the lateral movement of the lower jaw to the left, that the condyle of the left side stands still or does not move backward, it merely revolves or rotates in its socket, which is but a trifle. The right condoyle moves forward in the glenoid cavity fully half an inch, when at its farthest limit, causing the outer cusps of the upper, from the centrals to the last molar, to touch the outer and inner or buccal and lingual cusps of the lower on same side—the left—and on the opposite side—the right—we find only the inner cusps of the bicuspids and molars of the upper, to come in contact with the outer of the lower, and the centrals to the cuspids do not touch. And why so little surface touching on right side when the lower jaw is thrown to the left? You cannot masticate on more than one side at once, and when you throw the jaw to the left in the act of masticating, the food is upon that side, hence there is no necessity for the right side to have so much surface in contact. But why should it touch at all on the right? In order that the muscles of both sides should act equally, which could not be done if the teeth were not allowed to strike there, giving support to that side of the jaw, and equalizing the force brought to bear upon that side, although no food be there. If there were no touching of the teeth on that side while mastication is going on upon the left side, there would result, as a sequence, that peculiar movement of the lower jaw at the condyloid process, which makes it difficult to place in teeth for the aged or those even in early life, who have lost all the grinders on one side.

This form of triangle is necessary again for the purpose of giving the largest number of muscles a chance to act on both sides simultaneously and concentratedly, and thereby keeping the circle or arch of grinders down to their work, and equalizing the pressure on all sides. It enables the teeth on the side where the chewing is being done to arrange themselves when erupting, that they will be very nearly in a line with the left condyle, which is now passive on this side, and forms one point of the dividers in forming the arc of a circle; and by this condyle being where it is—four inches from the other—the molars and bicuspids, as well as the central of that side, all come into the most perfect contact, for chewing and incising, thereby carrying out this absolute natural law of the perfect adaptation of geometry and mechanics to her uses, and having no lost motion or function in any part.

Again, the triangle gives us an extra motion forward, which brings the lower teeth in contact with the upper to incise or cut off food presented there. This could not have been with any other arrangement than the triangle. One central point at the pharynx or on the median line would have been a single swivel joint, and have brought the teeth across each other in such a way that as soon as any lateral movement commenced, they would be drawn away from each other very rapidly, and but little surface be in contact. This triangle will enable you to get just the exact depth of underbite from the incisors to the last molar, and the exact shape of arches; and particularly that of the ramus, which is not a matter of chance—neither is the length of cusps on the bicuspids and molars mere chance. The type has been preordained, just as the nose on your face, or the peculiar shape of the eye, or any other one part of the body. And you will find that where a superior bicuspid has a cusp of a given length, the overbite will be governed and ruled by it. It cannot be otherwise. If in the arrangement of the teeth in the human jaw no type or design were laid down in conception or embryonic life, what malformed creatures we should be mentally and physically. And you will find that just in proportion as there is congenital insanity, or want of will or directing power, there will be a malformation of the teeth and their arrangement.

So much for the rationale of this triangular arrangement. You can only truly comprehend its beauties by studying this matter closely. The next step is, now that we know the exact shape of the jaw and its philosophy of form and functions, we must have at our command something so nearly approaching it, that we can place our models upon it, and thus again restore nature's "Lost Art." I believe I have it here so nearly that it will be found to answer our most fastidious notions of setting by a system, teeth on plate. In addition to the anatomy of the human jaw, I have it so arranged that with one base you can articulate any number of sets, or partial sets, without destroying the original plaster bite. The rings —or bows rather—are adjusted to the upper and lower sections or jaws of the articulator, and passed out or in, at pleasure, without even interfering with each other. The case can be grooved on in a year after as well as now, if the bows of the case are marked and preserved; and the economy of it is very marked, for two bows will not cost so much as another articulator; and besides are so cheap that they can be thrown away much easier than a more costly articulator. The whole apparatus is made of wire, giving you a clear view of every part within the arch, for the perfect articulation of the inner cusps; you will observe it has no set screw to hold the jaws apart, nor any device by which you can arrange the bite in the articulator. There is no room for guess work in rearing an artificial denture.

Before placing the wax models in the articulator, it will not be out of place to say a word about this arrangement of the wax on the base plate, and the selection of teeth in full sets. Always model the upper wax first, judging of the length of incisors by the trial of an artificial tooth in the mouth, such as in shape, length and width, as would look natural and appropriate, when held under the lip. This will enable you to get the height of wax and the contour after successful trial. The modelling of the wax on the upper plate is not arbitrary or fixed, so far as a definite law is concerned, in being able to work after a set pattern; here the true dental artist comes in. You get the length by trial of several blocks or single gum or plain teeth, as may be, as well as shade of same. As to the arch of upper you must add to and take from, making depressions, etc., until your judgment tells you it is correct. To aid amazingly in this work of art, draw out the patient in a smile or broad convulsive laugh, compel him to do so; nothing tends so to relax most universally every muscle and give true expression to the countenance. If the wax is not in keeping with symmetry you will see where the trouble lies. Look at them in front and on either side when they are laughing as a sculptor would upon his model. Be sure that the arch at the cuspids that form a double keystone to the arch stand out more prominently than any others. The superior first bicuspid should nearly always fall back somewhat behind the cuspids.

Now that the upper wax is correct the same rule applies to the lower. It is easy to make this conform to the upper; you may have to change the upper in some respects when tried with the lower, but not much. The length of wax at the molars may have to be trimmed to allow of equalizing the length of the teeth on upper and lower plates. Laughing and smiling will here again tell. Be sure to mark the centre at the median line, making marks or grooves through on either side, running from upper to lower for guide; they can be removed and are now ready for the articulator, with the bows pushed into their sockets in the base, which are retained by mere friction. The plaster models or casts with the wax articulation or bite thereon—and all fastened together by wax or cement to prevent being displaced from the cast—are now placed on this lower bow of the articulator, and the upper bow brought over upon the upper cast. Your eye soon detects whether the median line or wax is in the centre. To get the cast in proper place, have a pair of calipers four inches between points, and by it place the cast in position, with centre of lower teeth just four inches from the condyles on either side. Hold in position, while with plaster you secure the upper to the bow, and when hard the lower bow to the plaster cast in the same way.

You may ask where is the set screw to hold open the jaws of articulation after wax is taken off? I have never found it necessary in this kind of frame. Before taking off the wax, I take a pair of dividers, or a piece of wire bent with the points about one inch and a half apart, and mark, with one foot on plaster cast, and the other at cutting edge of wax, the bite at the median line. Do this for both jaws. To secure this height for future repairs, mark on each cast with the dividers, the distance apart or width of dividers, and this will always be your guide for height. Take off all the upper wax—except a section at the molars—first and let the lower remain as a guide, for the arch of the upper. The first block or tooth fitted on the upper when backed with wax, answers perfectly to keep the jaws of the articulator apart. The set screw would be in the way with the lateral movements. I stated that the length or depth of underbite in full sets, is restricted to the width of the jaws and length of the centrals, which it is presumed have been selected to suit the individual case. Knowing how much the underbite is to be, you can very nearly guess how much to cut out the bicuspids and molars on all the grinding surfaces, before any of them are fastened to the base plate, and how much arch upward at the ramus, from the second bicuspid backward and upward. If the underbite at the centrals is to be an eighth of an inch, then the bicuspids in the upper will have grooves between the cusps not quite so deep, and the molars still less. From the cuspids, then the cusps are less to the second molar; were the incisors to strike equally and directly on each other, there could be no cusps or would be of no use. The inner cusps of the upper should as a general rule be longer or higher than the outer. The outer cusp is more acute, the inner rounded. The lower the reverse—inner sharper and outer rounded, where the upper closes over the lower. For full sets you need but slight underbite, only enough to permit the lower to come forward and act as shears for cutting; at the same time it permits of cusps to both bicuspids and molars, and gives all. double amount of grinding surface; there being cusps that touch on palatal and lingual sides, at same time as the buccal. Always bear in mind that the curvature upwards at the ramus, of the upper set, is always in proportion to the underbite.

If for an upper set alone, you can tell how much the upper incisors should overbite, by looking at the curvature of lower molar teeth remaining. If an eighth of an inch out of line, the overbite should be fully so. This, when once understood, can give no trouble. The grooves in bicuspids and molars will form with the cusps buccal and lingual, an o. g. as seen in cut, to give double the grinding surface when worked laterally; besides giving double cutting edges. All these grooves can be cut out before any are fastened with wax, so nearly that but little touching will be needed when the lower is articulated to upper. The first bicuspid in the lower jaw should have but one cusp. This perfect design will be seen in the articulator why it should have but one. Two would not only be in the way of the tongue, but be of no use. Be sure that the groove in the upper is made nearer the buccal side, and for the lower or lingual side, for a reason which you will presently have explained. Now that the grooves are completed in the upper and all the teeth in place in the arch, we will articulate the teeth on the lower base. The height is soon ascertained by the dividers, and the central incisors tried on to see what changes will be needed. Fasten it temporarily with wax, and try it with the lateral motion and the points adjusted to meet all the surface on palatal side of upper teeth, when the lower is thrown to the side of the tooth being fitted. Cut from the cutting surfaces of each, whichever will make the most natural and strongest case. If for a very young subject be careful, but for a middle aged or elderly person do not scruple about the cutting edge and grinding surfaces, but sacrifice even the labial or palatal surface, for the sake of effect and usefulness.

I sometimes turn the buccal side of a molar inward, to save substance and get effect and for better adjustment; frequently for want of room at ramus I do this; and, occasionally turn buccal side upwards, for the grinding surface. If using blocks before the front ones are fastened securely to the base plate, and while they are temporarily in their right place, try the bicuspid blocks, to find out how much of the joint should come off of the incisors or the bicuspid block; or divide it. This will secure a better and more continuous joint, and give the lower better chance to be arranged to the upper. Before taking off too much of the joint of either of these blocks, try the lower incisor and bicuspid block temporarily on wax, to know where the cusps are going to come. Regulate the joints by this. You can make the groove in the lower blocks the reverse of the upper, and cut them all out before much jointing is done, taking care that the groove is now on the lingual side and that the buccal cusps are rounded, and the inner more acute as in the buccal of the upper. Never cut off any of the lingual cusps of the lower bicuspid and molar, such as are now made, as they are universally too short, and to get them long enough for service a large portion of the buccal cusps have to be cut down and rounded.

The inner cusps of the upper strike between the outer and inner of the lower, and, at the same time, these cusps should be long enough to allow in the lateral movement, the incisors and cuspid on that same side, to touch simultaneously all the surface from the central to the last molar. If they do not, then your remedy is to make the groove deeper in both upper and lower, or perhaps the lower only, or the upper only. Experience here will soon teach you which. When you have all the cusps touching inner and outer, and the front one, take the opposite bicuspid and do likewise; and with the additional precaution when the lower jaw of the articulator is turned to the left, to make the inner cusps of the upper, strike the outer cusps of the lower, and vice versa, when thrown to the lateral right or left. The molars must have the same rule applied, with yet another additional point of great importance.

The curvature of the ramus must be made to conform to the depth of overbite, so that when the lower jaw is thrown to the right, the outer and inner cusps of both upper and lower sets on that side come together at the same time that the bicuspids and incisors do; but the curvature should be great enough to permit on the opposite side of the second molar tooth in the lower, which slides forward to meet the first molar in the upper, apparently moving backward. If they were on a plane, they would never touch, on account of the jaws opening as they move laterally to the right or left; to mount up on the cusps of the incisors, an eighth of an inch, which would not allow the molars to touch, if on a straight line backward. But inasmuch as on the plane of grinding surface the first upper molar stands higher in the upper plane, the sliding forward of the lower jaw in the glenoid cavity brings the higher second molar in the lower, in continuous contact with the first superior molar, as well as both outer and inner cusps of bicuspids and molars of the upper and lower jaw. This is specially done to equalize the pressure and force on both sides or parts of the dental arches. This permits of the most compensating arrangement of the teeth for equalizing the action of muscles on both sides simultaneously, and getting the greatest amount of grinding surface at each movement. This arrangement of bicuspids and molars is found in nearly all the lower animals; the incisors, however, never touch when the jaws are in lateral movement. Turn the lower jaw to either side and the effect is the same. As I before said, but one side of the mouth can be used at the same instant, leaving the other free to balance the other side at work.

If the upper arch of incisors of the natural teeth should be broad or deep on account of the thickness of the base or body of the incisors, or where they are much inclined to protrude, then the arch at the ramus is not so great. In artificial sets this need never occur, carrying out the same rule in nearly every case, of controlling the curvature at the ramus, by the depth of overbite, and length of cusps of bicuspids. This system holds good in partial sets as well.

This constitutes all that is necessary to be said on articulation proper; it remains only to give a few points having a bearing on the perfection of the same. Select the broadest grinding surfaces to bicuspids and molars, that the bolus of food may be held securely on their faces, taxing less the muscles of the face engaged in mastication. Narrow surface would rather tend to cut the food than grind it. This is of no mean importance in rendering artificial teeth of greatest use.

To produce the most natural effect the centrals should be the lightest in color, and the cuspids a shade or so darker, with a difference in color of all the back teeth. I prefer on this account to set plain teeth wherever admissible—and nearly all lower cases are so—and use different shades and arrange irregularly. The lower incisor teeth are mostly crowded, and I find to lap them over and distort them, even to a great extent, adds very greatly to their natural appearance. Don't be afraid of getting any case too irregular; very few natural sets can boast of perfect symmetry.

In conclusion, gentlemen, let me again impress you with the importance of cultivating mechanical art in your calling; for I can assure you that it will pay tenfold, in increasing your usefulness as operators in every department, and in giving you powers of conception, to lead the way to original ideas and more practical development.

Syracuse, N. Y.
PAT. JAN. 21, 1908

3 1198 06213 0336
N/1198/06213/0336X

B644
.692
Bonwill
Geometrical & mechanical
ws of articulation.

ISSUED TO
~~Ren~~ 3/1
~~B Jumar~~
A. Kent

FE 27 '52
MY 10 '65

~~MY 10 '65~~
JG

Library

3 1198 06213 0336
N/1198/06213/0336X

STO

TORA